Abstract No. Mura0248

Structural Development of Natural and Synthetic-Isoprene Rubbers during Uniaxial Deformation by In-situ X-ray Diffraction using a Synchrotron Radiation

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Beamline(s): X27C

Introduction: Natural rubber is a typical elastomer with its low initial modulus (Young's modulus), high breaking stress, high draw ratio and rapid retraction to the initial state. It is well known that the natural rubber crystallizes when it is drawn above strain = ca. 2.5 at room temperature. However, the effect of the network structure of the rubber molecules on the relationship between crystallinity and strain (or stress) has not been well understood yet.

In this study, crystallization of natural and synthetic-isoprene rubbers during uniaxial deformation was studied by in-situ synchrotron x-ray diffraction. The main purpose is to investigate the effect of the crosslink density of vulcanized rubbers (by sulfur and peroxide) on crystallinity and stress.

Methods and Materials: By using our newly designed stretching machine (Figure 1), fast structural changes during stretching and returning were investigated. Simultaneous measurements of x-ray diffraction, stress and strain were carried out. Rubber samples with different crosslink densities were studied.

Results: It was shown that the higher the crosslink density, the higher the stress and the lower the maximum strain are. Even on the rubber sample vulcanized by larger content of sulfur, considerably strong amorphous halo was observed up to strain = 5. This result indicates that most of polymer chains were in the random coil state. The crystalline reflections which appeared even at strain = ca. 3 were sharp, and accordingly, the molecules had good orientation in the stretching direction. Further analysis of the results is in progress.

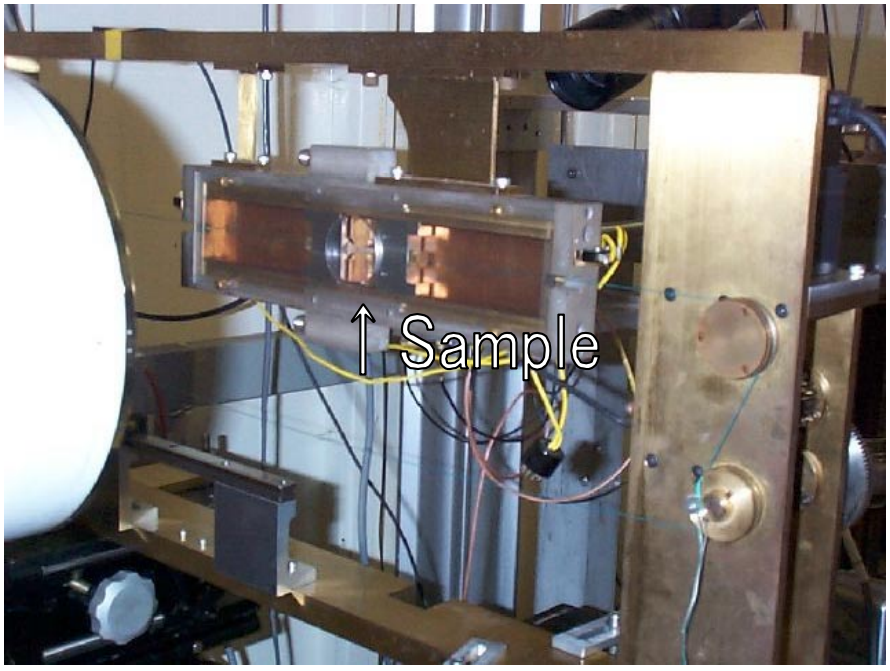

Figure 1. Stretching machine used in this study. Both sides of the rubber sample are stretched by the wire and almost the same location of the sample is subjected to the observation.